

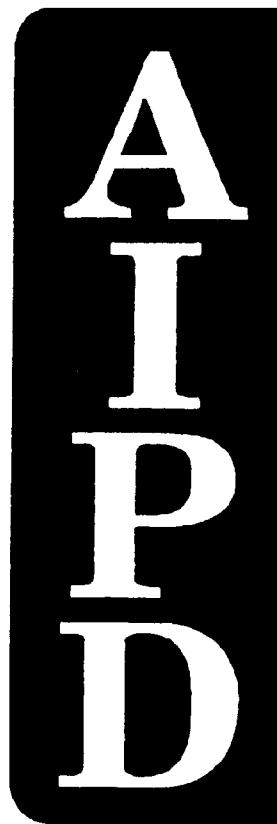
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SUBCOURSE  
MM0321

EDITION  
9

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## AM RADIO TRANSMITTERS

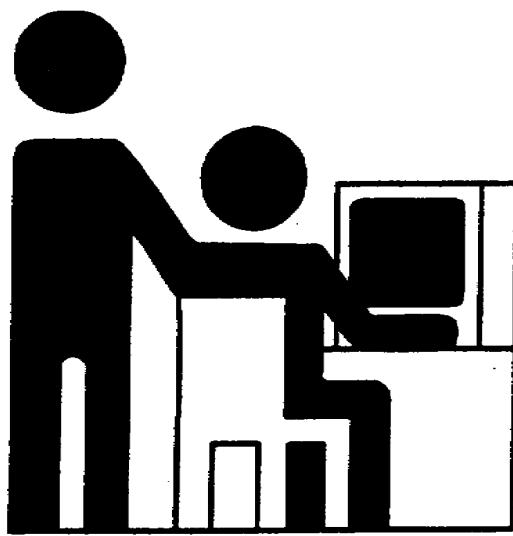


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THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

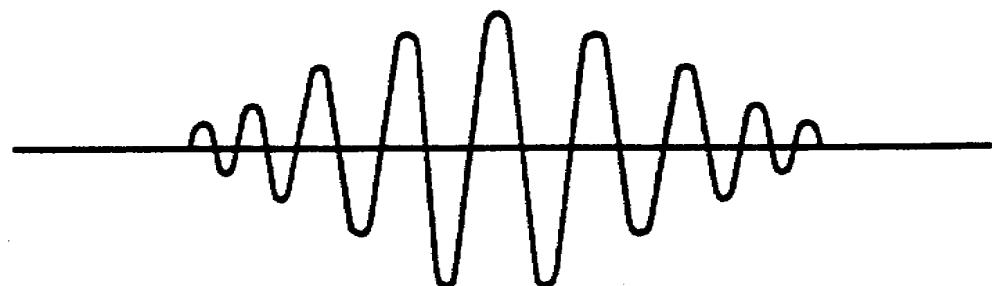
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**PLEASE NOTE**

Proponency for this subcourse has changed  
from Signal (SS) to Missile & Munitions (MM).

SIGNAL SUBCOURSE 321

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**THE PASSING SCORE FOR ALL ACCP MATERIAL IS NOW 70%.**

**PLEASE DISREGARD ALL REFERENCES TO THE 75% REQUIREMENT.**

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## SIGNAL SUBCOURSE 321, AM RADIO TRANSMITTERS

### INTRODUCTION

In the year 1896 the world unknowingly entered into a new era. In that year a man named Guglielmo Marconi sent the first wireless message a distance of two miles to a receiving device. Five years later Marconi's equipment successfully sent a signal across the Atlantic. The era of fast communications had dawned. Today there is no spot on the globe that cannot be reached by radio. We even communicate with our manned space capsules. The outgrowth of Marconi's first radio contact can be seen everywhere you look today. The military services, firemen, police departments, transportation industries, such as airlines, railroads, taxi companies and shipping lines, all use radio as their means of communication. Along with communication we have television, broadcast radio, stereo and hi-fi equipment, navigational equipment, and detection devices such as radar and sonar. These are all descendants of, or have evolved from, radio. The use of RF waves has indeed broadened since Marconi's first feeble attempt to use them to communicate.

However, none of these electronic miracles can do us any good unless we have people trained to maintain and repair them. Every TV picture or radio message that is sent must come from a transmitter.

This subcourse is designed to teach the principles of amplitude-modulated transmitters and a systematic method of locating troubles in these transmitters.

This subcourse consists of four lessons and an examination, as follows:

Lesson 1. CW Radio Transmitters

Lesson 2. Amplitude Modulation

Lesson 3. Transmitter Circuit Analysis

Lesson 4. Troubleshooting Procedures

Examination

Credit Hours: 9

You are urged to finish this subcourse without delay; however, there is no specific limitation on the time you may spend on any lesson or the examination.

Texts and materials furnished: Subcourse booklet with lesson exercises, lesson solutions and Examination.

Two Porta Punch Examination Answer Cards.

Return self addressed envelope

TM 11-665, C-W and A-M Radio Transmitters and Receivers, September 1952.

(EXTRACTED)

Reviewed and reprinted with minor revisions February 1979.

## LESSON 1

### CW RADIO TRANSMITTERS

SCOPE.....	Types of CW transmitters; classes of amplifiers; amplifiers as oscillators, buffers, frequency multipliers, power and voltage amplifiers; biasing; methods of keying.
CREDIT HOURS.....	1
TEXT ASSIGNMENT.....	TM 11-665, para 1-5; 52-56; 60-63
MATERIALS REQUIRED.....	None
SUGGESTIONS.....	None

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### LESSON OBJECTIVES

When you have completed this lesson, you will be able to:

1. Explain the principles of CW transmission.
2. Distinguish between the types of amplifiers, classes of amplifiers, and methods of biasing used in transmitters.
3. Identify the different methods used to key CW transmitters.
4. Determine which types and classes of amplifiers can be used as oscillators, buffers, frequency multipliers, power amplifiers, and voltage amplifiers.

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### DNI CORRECTIONS TO TM 11-665

Page 81, para 55a(1), line 1. Delete "transmitted" and substitute transmitter.

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### LESSON EXERCISES

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your solution by circling the letter opposite the correct answer in the subcourse booklet.

1. When checking over a new type of signal generator, you determine that the frequency range is from 200 to 2,500 Hz. This range of frequencies is associated with

- a. line-of-sight transmission.
- b. the sounds of human speech.
- c. long-distance radio transmission.
- d. the ultra high-frequency radio band.

2. Assume that during an engagement with Aggressor forces your unit obtained a transmitter calibrated in meters. With a dial scale of 3,000 to 4,500 meters, this transmitter can be used to send signals in the

- a. low frequency (LF) band.
- b. medium frequency (MF) band.
- c. high frequency (HF) band.
- d. very high frequency (VHF) band.

3. The international classification of 32A2 emission indicates the type used for the transmission of

- a. television signals.
- b. telegraph signals.
- c. telephone signals.
- d. facsimile signals.

4. Frequency instability of an oscillator caused by changes in the antenna-to-ground capacitance can be minimized by the use of

- a. class A bias.
- b. a buffer amplifier.
- c. voltage regulator tubes.
- d. a neutralizing capacitor.

5. Assume that a CW transmitter includes several intermediate amplifier stages to be used as either fundamental frequency amplifiers or as doublers. When a 10-MHz crystal is used in the oscillator stage, the transmitter can be arranged to transmit on a frequency of

- a. 50 MHz.
- b. 60 MHz.
- c. 80 MHz.
- d. 100 MHz.

6. When voltage amplifiers are used in the RF buffer stages of a radio transmitter, they are operated class

a. A.

c. C.

b. B.

d. AB.

7. When low-level modulation is used in a transmitter, the final power amplifier is operated as a

a. class A amplifier.

c. class C amplifier.

b. class B amplifier.

d. push-pull amplifier.

8. The tuned tank circuit in a class C amplifier plate circuit is designed to

a. operate only in push-pull.

b. be shocked into oscillation.

c. provide a series-resonant circuit.

d. change the sinusoidal waveform into pulses of RF energy.

9. The essential difference between a class B and a class C radio-frequency power amplifier in a CW transmitter is the

a. operating plate voltage.

b. value of bias voltage.

c. use of push-pull circuits for class B operation.

d. development of sinusoidal waveform in class C operation.

10. Neutralization is not required in a frequency multiplier circuit because

a. there is no grid tank circuit in a frequency multiplier.

b. there is no plate tank circuit in a frequency multiplier.

c. plate and grid tank circuits are tuned to the same frequency.

d. plate and grid tank circuits are tuned to different frequencies.

11. Assume that pentode tube, functioning as a class A amplifier, uses cathode bias. This type of bias is developed by the cathode resistor and the

a. control grid current.

b. screen grid current.

c. cathode current.

d. plate current.

12. The main advantage of grid-leak bias over other types is that grid-leak bias
- requires only a resistor and capacitor in parallel with the input load.
  - can develop a high bias voltage without using a separate voltage source.
  - remains stable even though excitation may vary.
  - protects the tube even when excitation fails.
13. Cathode bias is often combined with grid-leak bias in electron-tube circuits. This is to insure
- that the tube will have a stable cutoff point.
  - that there is sufficient bias to cut the tube off.
  - that the tube is protected if one method of bias should fail.
  - that if one type of bias fails the circuit will continue normal operation.
14. Interference from key clicks can be kept to a minimum by the use of
- keying relays.
  - primary keying.
  - cathode keying.
  - blocked-grid keying.
15. Keying a CW transmitter may cause the transmission of undesirable noise. Key click filters in the transmitter remove this noise by
- slowing down the transmission speed.
  - removing hazardous voltage from the key terminals.
  - retarding the rise and fall in the current that forms the dots and dashes.
  - producing clean-cut dots and dashes by instantaneously applying and removing power.

CHECK YOUR ANSWERS WITH LESSON 1 SOLUTION SHEET, PAGES 41 AND 42.

## LESSON 2

### AMPLITUDE MODULATION

SCOPE.....	Systems, methods, and levels of modulation; AF amplifiers, speech amplifiers; modulator stages; speech limiting.
CREDIT HOURS.....	2
TEXT ASSIGNMENT.....	TM 11-665, para 69-82
MATERIALS REQUIRED.....	None
SUGGESTIONS.....	None

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### LESSON OBJECTIVES

When you have completed this lesson, you will be able to:

1. Explain the principles of amplitude modulation.
  2. Categorize the systems, methods, and levels of modulation.
  3. Explain how RF and AF amplifiers are used in AM radio transmitters.
  4. Explain how voice waves are changed to audio voltages, and amplified.
  5. Explain how speech clipping is used to improve intelligibility.
- 

### DNI CORRECTIONS TO TM 11-665

Page 111, para 71a(1), line 41, change "5,000.5 kc" to: 5,005 kc.

Page 134, para 79d(1)(a), formula, change "Rp" to rp.

Page 144, para 81c(2), first sentence, change "V1 and V2" to V2 and V3.

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### LESSON EXERCISES

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your solution by circling the letter opposite the correct answer in the subcourse booklet.

1. If the modulation of a 500-watt RF carrier is reduced from 100 percent to 70 percent, sideband power is reduced by approximately

- a. 64 watts.
  - c. 128 watts.
  - b. 122 watts.
  - d. 186 watts.
2. The modulator stage of a transmitter is usually operated as
- a. an RF power amplifier.
  - b. an AF power amplifier.
  - c. an RF voltage amplifier.
  - d. an AF voltage amplifier.
3. The method of modulation in which the output varies with the input power while the efficiency of the modulated stage remains constant is called
- a. plate modulation.
  - b. cathode modulation.
  - c. grid bias modulation.
  - d. screen grid modulation.
4. Modulation is produced by changing either the dc input or the stage efficiency. The four methods that operate with the changing efficiency are identified as
- a. grid bias, screen grid, cathode, and suppressor grid modulation.
  - b. suppressor grid, plate, grid bias, and screen grid modulation.
  - c. cathode, screen grid, plate, and suppressor grid modulation.
  - d. grid bias, cathode, suppressor grid, and plate modulation.
5. Assume that the modulator stage in a transmitter uses constant efficiency plate modulation. 100-percent modulation is achieved when the instantaneous voltage on the plate of the modulated amplifier varies between
- a. zero and three times the dc operating plate voltage.
  - b. zero and one-half the dc operating plate voltage.
  - c. zero and twice the dc operating plate voltage.
  - d. zero and the dc operating plate voltage.
6. When grid bias modulation is used in a transmitter, the excitation voltage is kept at a low level to
- a. provide constant efficiency and output.
  - b. prevent the tube from being driven to cutoff.

c. prevent the modulated amplifier from oscillating.

d. prevent the grid from being driven to the zero grid bias point.

7. One favorable characteristic of a transmitter that uses low-level modulation is that

a. nonlinear amplifiers can be used.

b. the transmitter has high efficiency.

c. audio-frequency power requirements are relatively low.

d. the modulating voltage is applied to the final power amplifier.

8. What are the two types of modulation that are combined in center tap modulation?

a. Plate and screen grid modulation

b. Plate and control grid modulation

c. Plate and suppressor grid modulation

d. Screen grid and control grid modulation

9. The proper phase relationships between input voltage, plate current, and plate voltage appearing in a grounded-grid amplifier are shown in figure 2-1 in the sketch labeled

a. A.

c. C.

b. B.

d. D.

10. One of the characteristics of a grounded-grid amplifier is that it

a. requires neutralization to prevent oscillation.

b. operates best on very high frequencies.

c. is best suited for use as a modulator.

d. needs very little RF driving power.

11. Speech amplifiers in radio transmitters often include design features that accentuate certain frequencies in the usable speech range while attenuating all other frequencies. The primary purpose of this type circuit is to reduce the bandwidth and

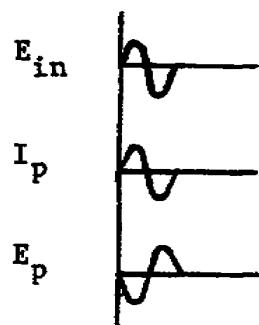
a. improve tonal quality.

b. retain intelligibility.

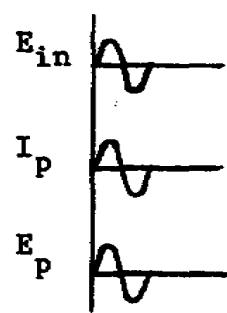
c. strengthen carrier power.

d. improve naturalness of speech.

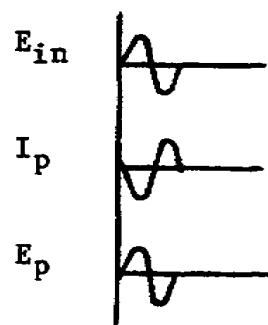
A.



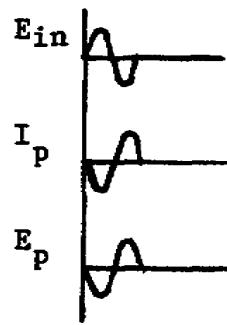
B.



C.



D.



**321-2-1**

Figure 2-1. Voltage and current relationships in a grounded-grid amplifier.

12. When comparing radio communication with broadcasting or public address work, the most important consideration must be the

- a. intelligibility of speech.
- b. sensitivity of the microphone.
- c. resulting naturalness of speech.
- d. maximum range of the transmitter.

13. Depending on the service for which they are designed, different types of microphones have varying degrees of sensitivity. Which type of microphone has the highest sensitivity?

- |             |            |
|-------------|------------|
| a. Velocity | c. Crystal |
| b. Dynamic  | d. Carbon  |

14. In the audio stages of a speech amplifier, which class of amplifier is usually used when voltage gain is the objective?

- |       |      |
|-------|------|
| a. AB | c. B |
| b. A  | d. C |

15. Good voltage regulation can be obtained in a modulator driver stage by using
- zero-bias modulator tubes.
  - a regenerative-feedback circuit.
  - driver tubes with high plate impedances.
  - a driver transformer with the highest possible step-up turns ratio.
16. Each class of modulator has its own operating characteristics. The class of modulator that gives the lowest plate circuit efficiency, power output, and distortion is the one operated as class
- AB1.
  - AB2.
  - A.
  - B.
17. The circuit of the volume compression system shown in figure 131 (TM 11-665) is so arranged that
- the speech-amplifier tubes are required to amplify less than normal.
  - rectifier tube V2 operates continuously until a level of approximately 100-percent modulation is reached.
  - a positive voltage applied to the cathode of tube V2 adjusts the modulation level to a predetermined value.
  - overmodulation is automatically prevented by applying AF voltage above a predetermined value to the suppressor grid of the speech-amplifier tube.
18. The purpose of both high-level and low-level speech clippers is to
- prevent the distortion caused by undermodulation.
  - provide means to eliminate the lower-than-average signal voltage.
  - permit the average peaks of the AF signal voltage to produce nearly 100-percent modulation.
  - eliminate the undesirable high and low audio frequencies that are present in speech but are not necessary for intelligibility.
19. In the low-level speech clipper shown in A of figure 132, TM 11-665, clipping occurs when the bias voltages of the clipper diodes are
- double the average value of the AF signal voltage.
  - equal to the average value of the AF signal voltage.

- c. slightly less than the average value of the AF signal voltage.
  - d. slightly greater than the average value of the AF signal voltage.
20. One advantage of tone-modulated transmission is that
- a. modulation can be adjusted to 100 percent.
  - b. it has a greater range than a CW transmitter of equal power output.
  - c. it has a greater range for less power output than a voice transmitter.
  - d. it provides all the frequencies necessary for good speech intelligibility.

CHECK YOUR ANSWERS WITH LESSON SOLUTION SHEET #2, PAGES 42 and 43.

## LESSON 3

### TRANSMITTER CIRCUIT ANALYSIS

SCOPE.....	Circuit analysis of multtube transmitters; interstage coupling; neutralization
CREDIT HOURS.....	2
TEXT ASSIGNMENT.....	TM 11-665, para 57-59; 64-66
MATERIALS REQUIRED.....	None
SUGGESTIONS.....	None

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### LESSON OBJECTIVES

When you have completed this lesson, you will be able to:

1. Identify the various methods of connecting the stages of a transmitter.
  2. Explain why a transmitter must be neutralized.
  3. Relate the methods used to neutralize a transmitter.
  4. Explain the function of each stage in an HF multtube transmitter.
- 

### DNI CORRECTIONS TO TM 11-665

Page 86, para 57c(1), line 5. Delete "cc" and substitute Cc

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### LESSON EXERCISES

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your solution by circling the letter opposite the correct answer in the subcourse booklet.

1. Figure 72 in TM 11-665 is the schematic representation of two capacitive coupling circuits. In schematic A, the load for the output signal from tube V1 is provided by

- a. inductor L1.
- b. capacitors C1 and C2.

- c. radio-frequency choke RFC.
  - d. capacitors C1 and C2, and inductor L1.
2. Figure 74 of TM 11-665 is a schematic representation of an untuned impedance coupling circuit. In this type of coupling circuit, harmonic frequencies will
- a. not be generated.
  - b. be amplified by the second tube.
  - c. be filtered by the RF choke in the grid circuit of the second tube.
  - d. be filtered by the capacitor in the grid circuit of the second tube.
3. The unity-coupled (one-to-one turns ratio) RF transformer is seldom used in military transmitters because
- a. it is very expensive.
  - b. the coupling cannot be changed.
  - c. it is too bulky and heavy for portable equipment.
  - d. the coupling is difficult to adjust for proper excitation.
4. Interstage coupling is used to insure that when RF energy is transferred from one stage to the next, it is done with a minimum amount of loading and power loss, providing sufficient energy to excite the next stage. If the two stages are separated by any appreciable distance, it would be advantageous to use
- a. capacitive coupling.
  - b. impedance coupling.
  - c. inductive coupling.
  - d. link coupling.
5. Assume that a series-resonant circuit has a capacitive reactance of 600 ohms and a circuit resistance of 4 ohms. If 2 volts are developed across the resistance, how much voltage is developed across the reactance?
- a. 4 volts
  - b. 150 volts
  - c. 300 volts
  - d. 600 volts
6. The method of interstage coupling that can be used in a transmitter to produce a voltage increase between the output of one stage and the input of the next is
- a. link coupling.
  - b. impedance coupling.

- c. inductive coupling using a series-resonant circuit as the input circuit.
  - d. inductive coupling using a parallel-resonant circuit as the input circuit.
7. Assume that you are slug-tuning the inductor in a tuned circuit. When you move the iron core into the coil you are causing the
- a. inductance to increase and the resonant frequency to increase.
  - b. inductance to decrease and the resonant frequency to decrease.
  - c. inductance to increase and the resonant frequency to decrease.
  - d. inductance to decrease and the resonant frequency to increase.
8. The process of preventing self-oscillation in an RF amplifier is known as
- a. parasitic suppression.
  - b. degenerative feedback.
  - c. neutralization
  - d. damping.
9. Figure 98 of TM 11-665 is a schematic diagram of a simple transmitter. Capacitor C5 is a variable capacitor used in order to
- a. permit conversion of this stage into an oscillator.
  - b. provide the correct amount of regenerative feedback.
  - c. provide the correct amount of degenerative feedback.
  - d. insure that the feedback signal is exactly 180° out of phase with the input signal.
10. Intermediate amplifier tube V6 in figure 99, TM 11-665, needs no neutralization because the
- a. plate voltage is greater than the screen voltage.
  - b. interelectrode capacitance is very small in a pentode.
  - c. output frequency in an intermediate amplifier is always different from the input frequency.
  - d. degenerative feedback through the interelectrode capacitance is sufficient to prevent oscillation.
11. What type of neutralization is used in push-pull circuits?
- a. Link
  - b. Grid
  - c. Plate
  - d. Cross

12. What type of neutralization does not rely on degenerative feedback to prevent self-oscillation?

- a. Link
- c. Cross
- b. Plate
- d. Inductive

13. Interfering frequencies may be transmitted because of parasitic oscillations. Sources of parasitic oscillations in a transmitter include

- a. incorrect bias.
- c. a defective fuse.
- b. defective tubes.
- d. degenerative feedback.

14. The purpose of inserting a parallel combination of resistor and coil into the grid circuit of the final amplifier in a transmitter is to

- a. aid grid-leak bias and make the amplifier operate class C.
- b. broaden the bandwidth of the amplifier.
- c. reduce parasitic oscillations.
- d. eliminate harmonic distortion.

15. When inductive coupling is used in a transmitter, harmonic frequencies are often transferred through electrostatic coupling. What can you do to eliminate this transfer of harmonics and still have a maximum transfer of desirable frequencies?

- a. Use a Faraday shield.
- b. Space the inductors farther apart.
- c. Space the inductors closer together.
- d. Use high-power frequency multipliers.

16. Assume that an antenna presents a capacitive reactance to a transmitter. To provide the maximum transfer of power from the transmitter to the antenna you would

- a. increase inductance in the antenna coupling circuit.
- b. decrease inductance in the antenna coupling circuit.
- c. install a capacitor in parallel with the antenna.
- d. detune the final RF amplifier.

17. When the antenna coupler of a transmitter is tuned to resonance, the load that the antenna presents to the transmitter is

- a. changing.
- b. resistive.
- c. inductive.
- d. capacitive.

## SITUATION

Assume that you are assigned to a signal company as a radio repairman. One of your first duties is to familiarize yourself with the transmitters you must maintain. One of them is similar to the one shown in the schematic in figure 99 of TM 11-665.

Exercises 18 through 20 are based on the above situation.

18. The source of the plate and screen grid voltages of oscillator V1 is the 400-volt power supply. If the supply voltage decreases 10 volts, what voltage values appear on the plate and screen grid?

- a. 200 volts on the plate and 210 volts on the screen grid
- b. 210 volts on the plate and 200 volts on the screen grid
- c. 210 volts on both the plate and screen grid
- d. 200 volts on both the plate and screen grid

19. Assume that the input signal to V6 has a frequency of 31.8 MHz. If the crystal oscillator (V3) is operating at a frequency of 2.65 MHz, the first and second multipliers must be acting as

- a. a tripler and a quadrupler.
- b. a doubler and a quadrupler.
- c. a doubler and a tripler.
- d. quadruplers.

20. Meters are installed in critical transmitter circuits to facilitate tuning. When meter M2 is connected to points G and H, the meter indicates the value of

- a. plate supply voltage for V4.
- b. plate voltage for V4.
- c. plate current for V4.
- d. tube current for V4.

CHECK YOUR ANSWERS WITH LESSON SOLUTION SHEET #3, PAGES 43 AND 44.

## LESSON 4

### TROUBLESHOOTING PROCEDURES

SCOPE.....	Transmitter troubleshooting procedures; analysis of block and schematic dia- grams of a radiotelephone transmitter
CREDIT HOURS .....	2
TEXT ASSIGNMENT.....	Addendum 1 TM 11-665, para 83-84; Attached Memorandum, para 4-1
MATERIALS REQUIRED.....	None
SUGGESTIONS.....	Read the assignment in the order listed

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### LESSON OBJECTIVES

When you have completed this lesson, you will be able to:

1. Follow a planned procedure to save time and effort in troubleshooting a transmitter.
  2. Use a block diagram to localize a trouble to a stage.
  3. Relate some of the uses for resistors, capacitors, inductors, and tubes used in the various circuits.
-

ADDENDUM I

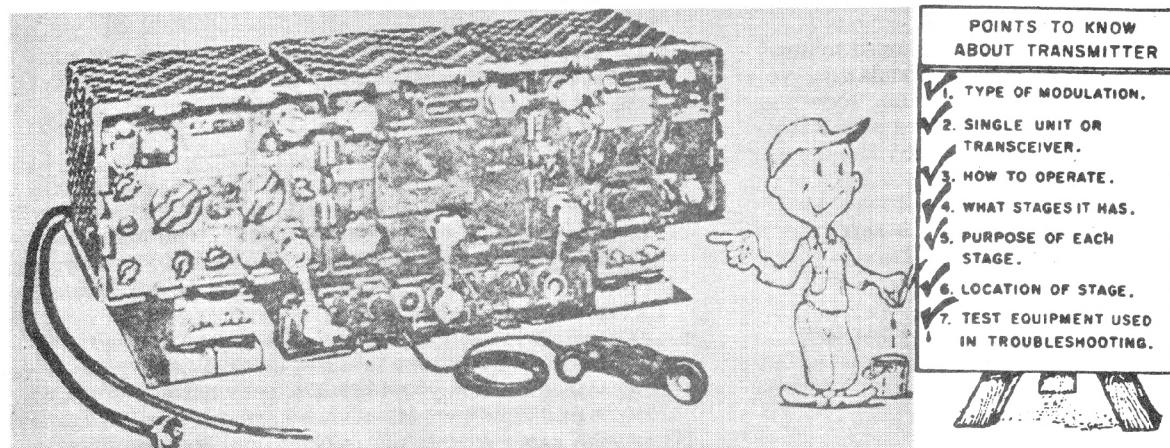


Figure 1. Become familiar with the transmitter you're working on.

### 1. INTRODUCTORY INFORMATION

a. One of the most important ways to gain skill in repairing radio equipment is to DEVELOP A LOGICAL METHOD OF TROUBLESHOOTING -- one that can be followed for all types of sets. By following a logical procedure, you'll avoid the hit-or-miss methods that do nothing more than waste time. In addition, you will soon acquire the skill that will eventually put you in the "expert" class.

b. This text explains how to troubleshoot radio transmitters in a logical, step-by-step manner. However, before discussing the actual procedure, you must have a reasonably good working knowledge of the transmitter you're to repair. There are

many types of radio transmitters and it's impossible to remember all the important points of each, but you can approach each transmitter by learning the important points about it as shown in figure 1. It's like taking inventory of what you have to work with before you start and it will help speed you into troubleshooting. Reviewing the questions and learning the answers given in the chart on page 2 will also help you become familiar with each transmitter.

### 2. COMPARISON OF AM AND FM

a. Figure 2 is a block diagram of a typical AM transmitter. Actually it's the transmitter section of Receiver-Transmitter RT-77/GRC-9. When you speak, voice frequencies detected by the

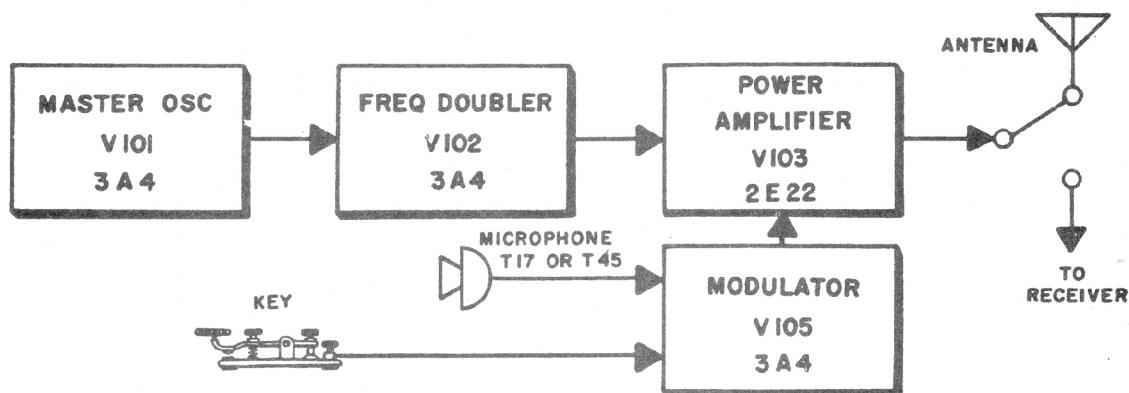


Figure 2. Block diagram of transmitter section of RT-77/GRC-9.

**QUESTIONS AND ANSWERS FOR TAKING INVENTORY**

**Questions**

1. Is the transmitter used to send voice by amplitude modulation, voice by frequency modulation, code messages by continuous-wave, or teletypewriter messages by frequency-shift keying?
2. Is the transmitter a separate unit or part of a receiver-transmitter combination (transceiver)?
3. Do you know how to operate the transmitter?
4. Do you know the stages that make up the transmitter, their location, and what each stage is supposed to do?
5. Are you familiar with the type, purpose, and use of the test equipment you'll need to troubleshoot the transmitter?

**Answers**

1. Get acquainted with the Description and Data section in the TM on the equipment. Examine particularly the Technical Characteristics paragraph.
2. This answer can be easily found. A nameplate on the equipment gives you this information. For example, one common receiver-transmitter is labeled Receiver-Transmitter RT-77/GRC-9.
3. Usually the second or third chapter of the TM covering the equipment provides this information. If you can't find it in the TM, chances are another TM covering the same set has the information. For example, a TM on Radio Sets AN/GRC-3 through AN/GRC-8 covers the complete set with all of its components, including the operating instructions. However, there are other TM's which deal with specific components of the set like Receiver-Transmitter RT-70/GRC. The TM on the individual components gives you additional information not available in the TM covering the complete set.
4. Unless you've been working on the particular transmitter for a long time, this is a pretty tall order. A good idea is to start with a functional block diagram usually found at the beginning of the theory of equipment portion of the TM. Then examine the schematic which is usually provided as a foldout sheet.  
If you are in doubt about the purpose and function of any stage, review the theory of the stage. Then remove the transmitter or transceiver from its case and locate the stages in it. As a guide, use the photographs in the TM. The photographs usually identify stages and components within the stages.
5. You'll have to get all the TM's on the equipment. Usually, one or more of the TM's will be P-publications -- Repair Parts and Special Tools Lists (RPSTL's). For example, Radio Set AN/VRC-34 has two P-publications: TM 11-5820-453-20P and TM 11-5820-453-35P. The P-publications tell you which repair functions you are authorized to perform and the tools and test equipment you need to perform repairs. The lists in the P-publications are called the Maintenance Allocation Chart and the Allocation of Tools for Maintenance Functions.

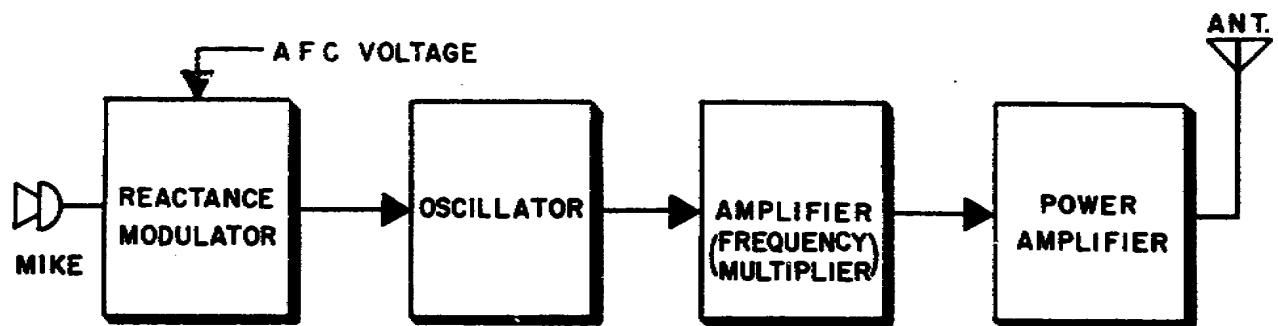


Figure 3. Block diagram of a typical FM transmitter.

microphone (T17 or T45) are amplified by the modulator. The output of the modulator is then used to **AMPLITUDE-MODULATE** the carrier frequency in the power amplifier. Notice that a key can also be used to transmit modulated continuous wave (CW) signals.

b. Figure 3 is a block diagram of a transmitter in which the carrier is **FREQUENCY-MODULATED**. The voice frequencies from the microphone are fed to a special type of modulator called a reactance modulator. The output of the modulator causes the frequency of the oscillator to change.

(1) The speed at which the oscillator changes frequency depends upon the frequency of the voice signals fed into the microphone.

(2) The amount that the frequency changes from the original carrier depends upon the amplitude of the voice frequencies from the microphone.

c. The output of the oscillator is amplified and the frequency is multiplied by the next section of the transmitter. The frequency modulated carrier is then sent out by the transmitting antenna.

d. By comparing the AM and FM transmitter block diagrams, you can see that the

major difference between them is how the carrier frequency is made to carry information. One varies the amplitude of the carrier (AM) and the other varies the frequency of the carrier (FM).

### **3. GENERAL TROUBLESHOOTING PROCEDURE FOR TRANSMITTERS**

a. It would be fine if you could pick up a book that would tell you how to locate any type of trouble in any transmitter. Unfortunately, it's impractical to prepare such a book. First, because there are too many different troubles that are likely to occur and, second, there are too many differences that exist between the different transmitters.

b. There is, however, a general troubleshooting procedure that is good for all transmitters. Once you understand and follow this general procedure you'll be able to approach each defective transmitter in the same way. You'll be able to avoid the old "try this -- try that" technique that will lead nowhere.

### **4. THE TECHNICAL MANUAL**

a. The first thing to do is to get the TM on the specific equipment to be repaired. The TM contains all the schematic diagrams and the detailed troubleshooting procedures needed.

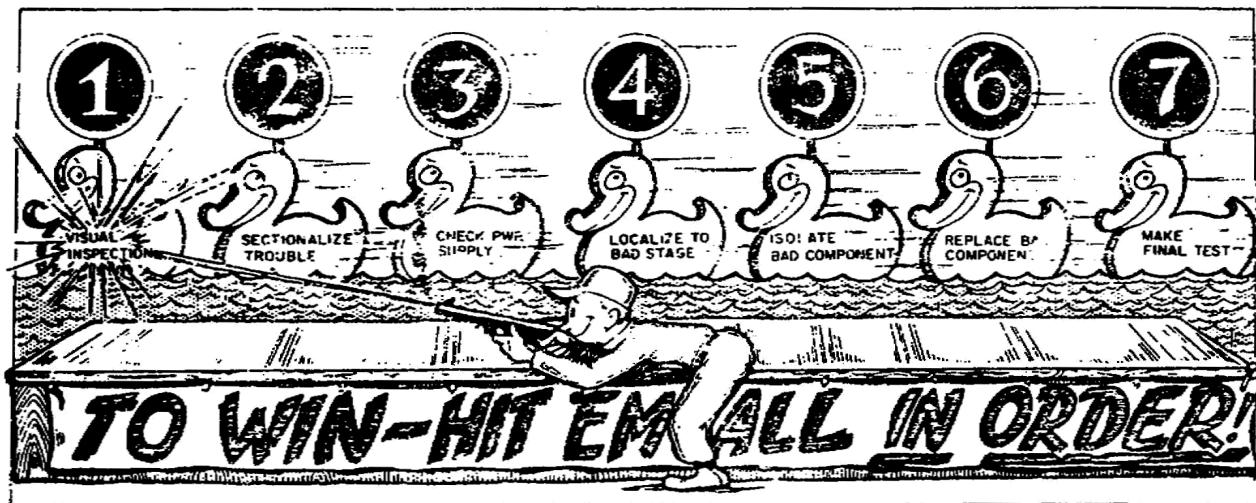


Figure 4. On your way to a perfect score.

b. With the defective set or transmitter and the TM for that equipment in front of you, you're ready to start. The procedure to follow is given in figure 4 and the following steps. The first two steps are used if you have a complete radio set.

- (1) Perform a VISUAL INSPECTION of the complete set.
- (2) SECTIONALIZE the trouble to a unit of the set.
- (3) CHECK the power supply.
- (4) LOCALIZE the defective transmitter stage.
- (5) ISOLATE the faulty component.
- (6) REPLACE the faulty component.
- (7) Make a FINAL TEST.

c. Each step in the procedure is important and should be followed in sequence. Each step is discussed in the following paragraphs and the specific things that should be done in each step are explained.

#### 5. VISUAL INSPECTION OF A COMPLETE SET

- a. Many equipment faults can be found by visually inspecting the complete radio set.

For example, suppose your next job is to fix an AM transceiver. After reading the repair order, give the outside of the set a complete visual inspection. Common troubles overlooked by the operator may be the only thing that's wrong.

- b. A list of the important things to check is given in figure 5.

#### 6. NEXT, SECTIONALIZE THE TROUBLE

a. If an initial visual inspection does not disclose an obvious fault, you must find out which unit in the radio set is bad. In Radio Set AN/GRC-10, for example, the main units that make up the set are Radio Receiver R-125/GRC-10, Radio Transmitter T-235/GRC-10, Radio Set Control C-632/GRC-10, and the Dynamotor-Power Supply DY-94/GRC-10. Sometimes the repair order may indicate which unit is faulty, but don't rely exclusively on the repair order. Prove to yourself that the unit specified in the repair order is really at fault.

- b. What procedure can be followed to find out which unit is at fault? The best place to start is with the maintenance portion of the TM. This part of the TM has charts and lists to help you determine if all the units that make up the set are working properly.

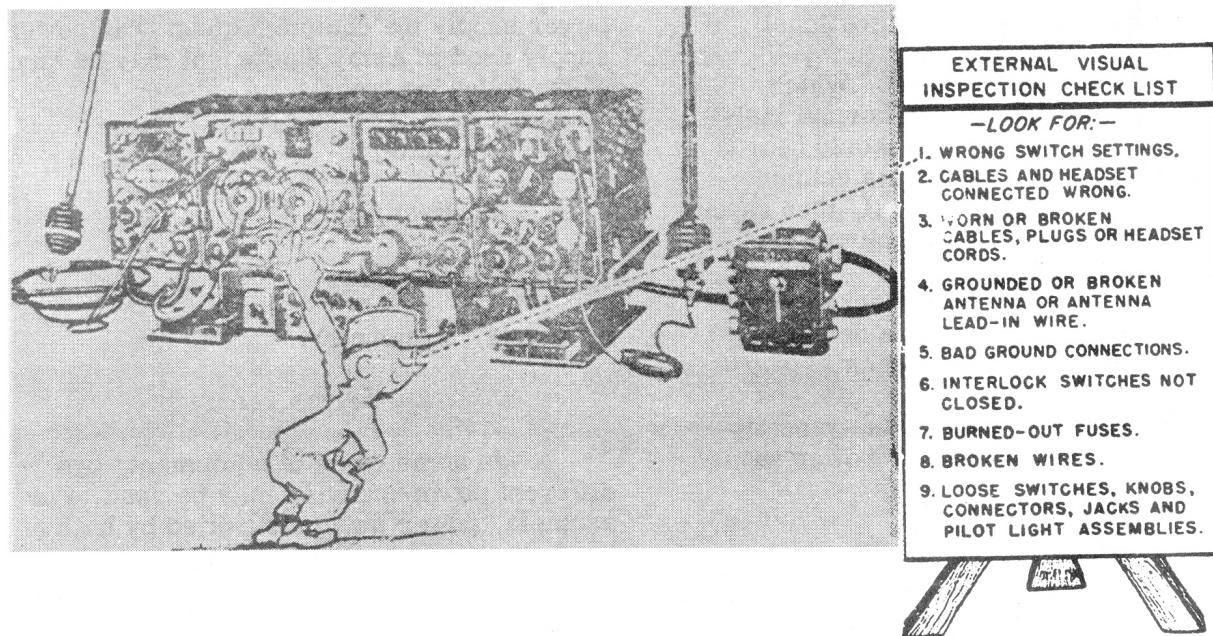


Figure 5. Give the complete set a thorough visual inspection.

c. The TM used for Radio Set AN/GRC-10, for example, has an Equipment Performance Check List divided into columns designated Item, Action or condition, Normal indications, and Component to be checked. Part of the check list is shown in figure 6.

(1) Item. This column gives the item to check and the order in which to make the checks.

(2) Action or condition. This column specifies how to set the operating controls and switches. In some cases it

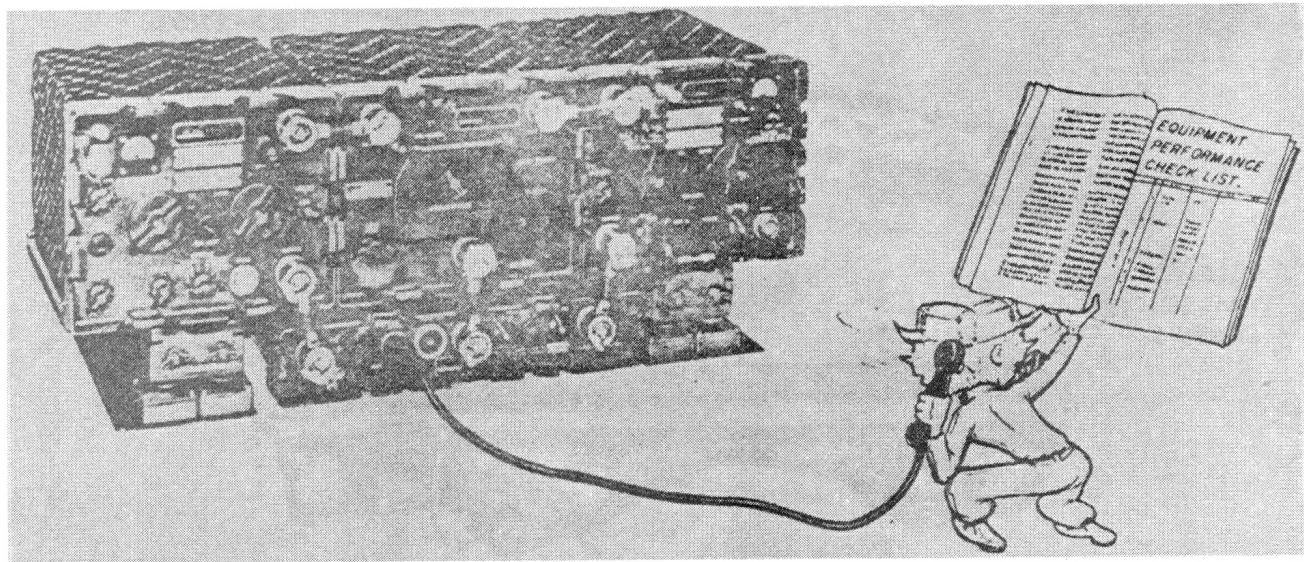


Figure 6. Using an equipment performance check list.

explains how to check the indications given in the next column (Normal indications).

(3) Normal indications. Which meter is to be read, what the normal indication is, or what signal you should hear if everything is OK is given in this column. If the indications are not normal, then check the unit specified in the next column.

(4) Component to be checked. This column designates the probable defective unit when normal operating indications are not obtained. For Radio Set AN/GRC-10, for example, it tells whether the transmitter, receiver, control unit, or power supply is bad.

d. Let's assume that the Equipment Performance Check List indicates the transmitter is defective and go to the next step of the troubleshooting procedure.

## 7. CHECKING THE POWER SUPPLY

a. The next step in the troubleshooting procedure is to check the power supply. A transmitter must have power to operate; therefore, before anything else can operate properly or any circuit be checked, the power supply must be working correctly.

b. First of all, find out what type of power supply the equipment has. The power supply used in Army equipment may be any of the following types:

- (1) Battery.
- (2) Rectifier.
- (3) Vibrator.
- (4) Dynamotor.
- (5) Hand-driven generator.

c. In some types of equipment, two different power supplies may be used. For example, power may be supplied by both a hand-driven generator and a battery.

## 8. BATTERY POWER PACKS

a. Battery power supplies or battery power packs, as they're called, are most generally used to furnish energy to small portable transceivers. The AN/PRC-6, -8, -9 and -10 are good examples of battery-operated equipment. The battery power supply in the AN/PRC-6 is shown in figure 7.

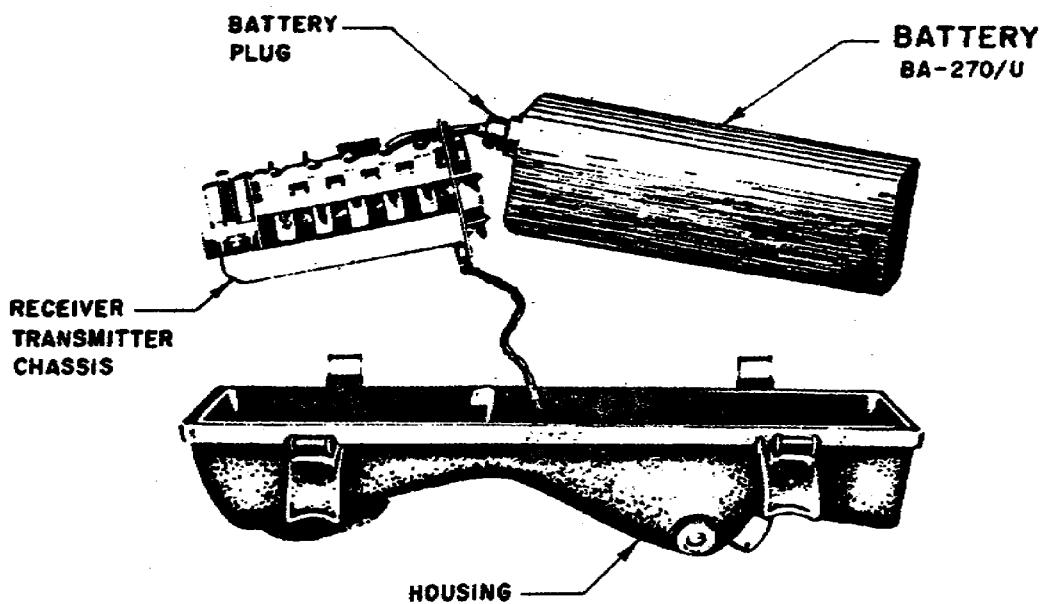


Figure 7. The battery power supply used in the AN/PRC-6.

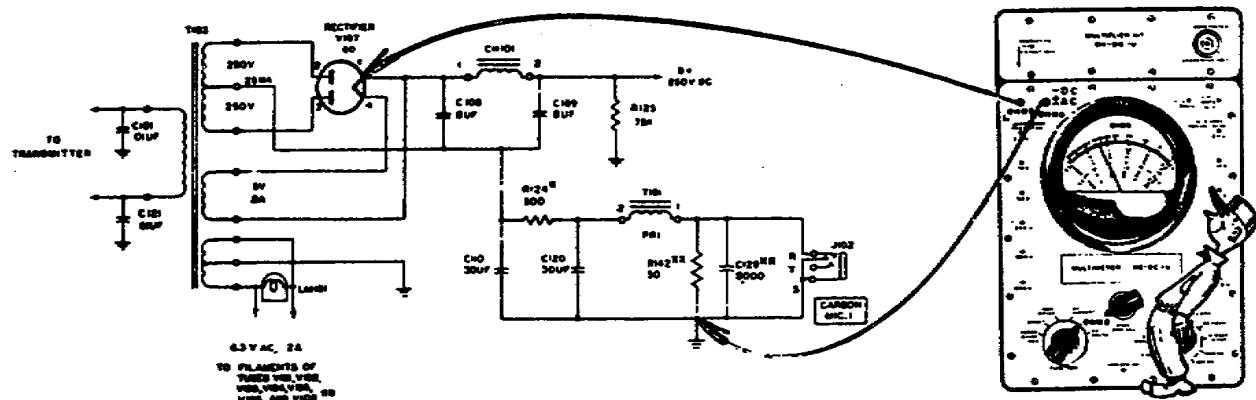


Figure 8. Making KEY CIRCUIT CHECK in a rectifier-type power supply.

b. Weak or unstable operation is usually caused by weak batteries. If these symptoms appear, try substituting a new battery. Another important thing to watch out for is any sign of corrosion around battery terminals.

c. Battery cables are often sources of trouble. To check for an open battery cable, first pull out the battery plug from the battery and then look for the other end of the cable which is usually terminated at a jack. Make a continuity check with an ohmmeter between each lettered terminal on the plug and the corresponding lettered terminal on the jack. A reading of 0 ohms should be obtained for each measurement. If infinity is read between two matching terminals it means that part of the battery cable is open.

#### 9. RECTIFIER-TYPE POWER SUPPLIES

Figure 8 is a schematic of a typical rectifier-type power supply. This one supplies energy to a speech amplifier that is used with a medium-power transmitter.

a. When checking a power supply of this type, DON'T TURN ON POWER until you have made a resistance check of the B-Plus circuit. This will prevent causing further damage to the circuit components. A resistance check is usually given in the maintenance chapter of the TM's.

b. In the circuit shown in figure 8, the resistance check is made by measuring the resistance between pin 1 (or pin 4) and ground as shown by the meter connections. If the circuit is OK, the meter should indicate about 57,000 ohms.

c. After the resistance check, the best way to find trouble in a power supply is to use the troubleshooting chart in the maintenance portion of the TM. This chart usually gives a symptom that can be seen or heard, the probable trouble that will cause this symptom to appear, and a column on how to correct the trouble. Generally speaking, though, the troubles listed below are the more common troubles that occur in any rectifier-type power supply.

(1) Bad rectifier tube.

(2) Open filter choke.

(3) Filter choke shorted or choke leads shorting to chassis.

(4) Open or shorted power transformer windings. In practically all cases, if the transformer windings are shorted, the line fuse will blow.

(5) Open filter capacitor. An open filter capacitor usually causes B-plus voltage to drop or an objectionable amount of ripple to appear in the B-plus voltage or both.

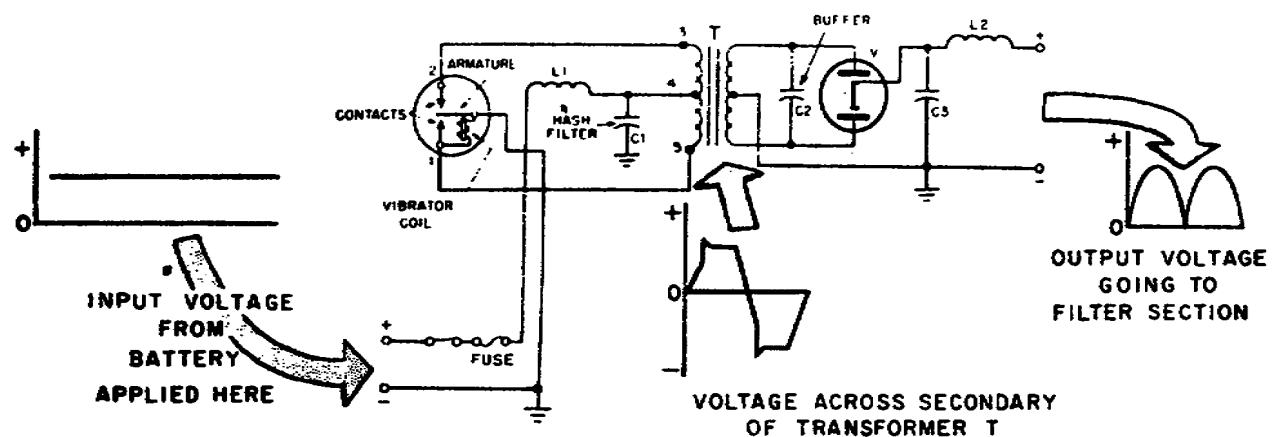


Figure 9. Schematic of vibrator power supply with waveshapes.

(6) Shorted filter capacitor. With few exceptions a shorted filter capacitor will cause the line-fuse to blow.

(7) Open bleeder resistor (voltage divider).

#### 10. VIBRATOR-TYPE POWER SUPPLIES

a. Vibrator-type power supplies are used most extensively with radio equipment mounted in vehicles. Figure 9 shows a basic vibrator circuit. Briefly, the circuit works this way.

(1) The low dc voltage (6, 12 or 24 volts) from the battery is changed to pulsating dc by the vibrator.

(2) This pulsating dc then induces an ac voltage in the secondary of transformer T.

(3) The ac voltage is then rectified by V1 and coupled to the filter section.

(4) The output of the filter is a relatively high dc voltage ready to furnish the necessary potentials for the radio set.

b. One of the most common causes of complete failure of a vibrator-type power supply is a defective vibrator. If the vibrator is operating normally, you'll hear a steady buzz and if you touch it you'll also feel a slight vibration. Some of the other

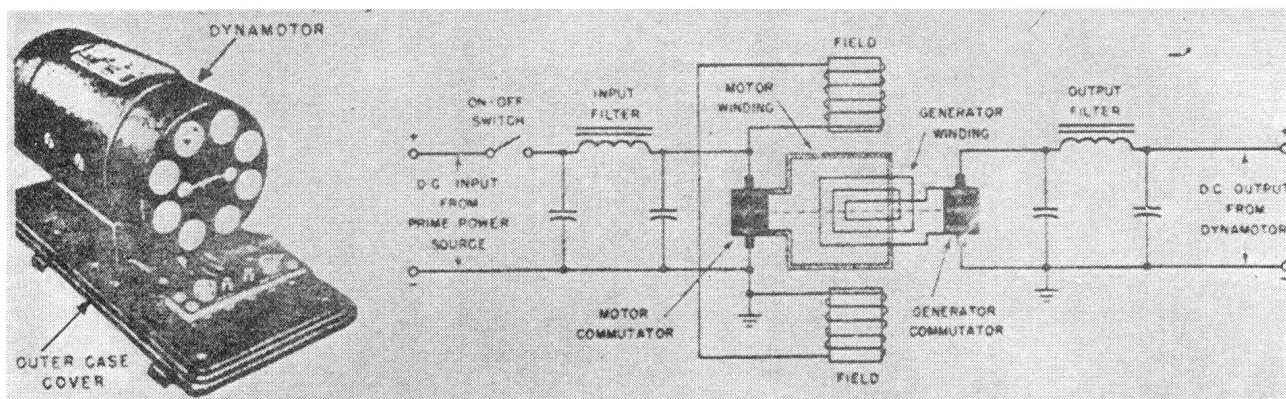
common troubles that occur in vibrator-type power supplies are:

- (1) Bad rectifier, voltage regulator, and ballast tubes.
- (2) Open transformer windings.
- (3) Open filter choke.
- (4) Shorted or open filter capacitor.
- (5) Defective relays.
- (6) Broken or disconnected plugs.
- (7) Broken or burned jacks.
- (8) Shorted buffer capacitor.

c. To develop a system for locating the troubles just mentioned, make use of the troubleshooting charts in the maintenance portion of the TM. Often, a chart is provided to help you find the faulty section of the power supply. Once the faulty section is found, you can pin-point the exact component that's causing the trouble.

#### 11. DYNAMOTOR-TYPE POWER SUPPLIES

Dynamotors are used to change a dc voltage to a higher or lower dc voltage. This is done by using a dc motor to drive a dc



**Figure 10. Dynamotor and schematic of a dynamotor power supply.**

generator. The energy to drive the motor is usually obtained from the battery in the vehicle or aircraft in which the radio set is mounted.

a. Figure 10 shows a dynamotor and a schematic of a dynamotor power supply. Notice that the motor and generator are combined on a single frame. This is true of all dynamotors.

**CAUTION: DON'T TOUCH THE COMMUTATOR -- YOU MAY BE KILLED.** Some dynamotors put out a high voltage (1,000 volts in the AN/GRC-19).

b. If the dynamotor being checked does not turn, the things to look for are a low battery voltage, a loose or broken cable connecting the battery to the dynamotor, and improper or defective wiring (use wiring diagram in TM).

c. If the dynamotor operates but there is no output, look for the following:

(1) Worn dynamotor brushes. Those that are less than one-quarter inch long, measuring from the commutator to the brush-pressure spring, should be replaced. Be sure the polarity mark is correct when replacing worn brushes and watch for broken brush pigtails.

(2) Dirty commutator. If the dynamotor commutator is accessible, a piece of

fine sandpaper (No. 00 or 000) can be held against the commutator while the dynamotor is operating. The sandpaper is wrapped around an insulated block and then held lightly against the commutator.

(3) Open or shorted field windings. A continuity check is used as a test. The correct resistance readings can be found in a table usually given in the maintenance portion of the equipment TM.

d. Dynamotor power supplies have filter components similar to those found in vibrator and rectifier power supplies. These filter capacitors or chokes can become open or shorted. The best way to check these is to first disconnect the dynamotor at the output (generator) terminals. Then make an accurate resistance check of each component.

## 12. HAND-DRIVEN GENERATORS

Hand-driven generators are used most often to supply power to radio equipment that is portable but requires more power than batteries can provide.

a. What would lead you to suspect that a hand-driven generator (small to medium size) is bad? One important indication is if you set all the transmitter controls correctly, but the dial light doesn't go on and the transmitter does not operate.

b. To find out why the hand-driven generator is not working properly, turn to the

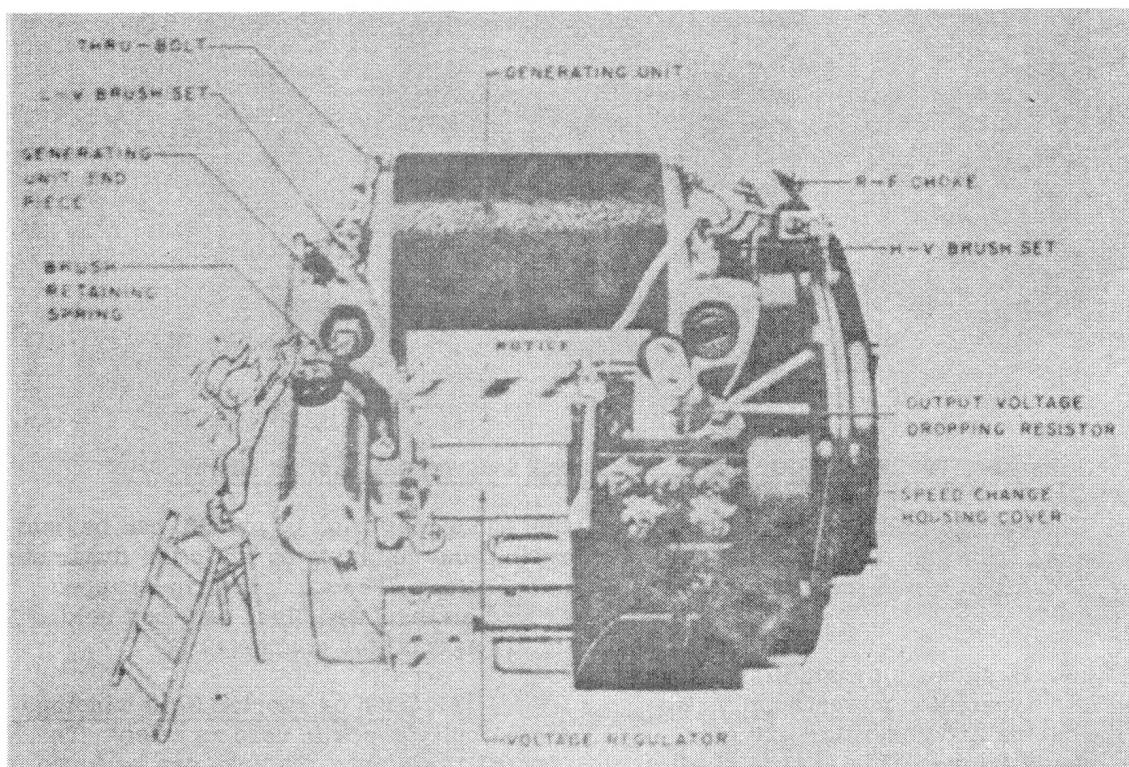


Figure 11. Replacing brushes in a hand-driven generator.

troubleshooting chart in the maintenance portion of the TM. This chart indicates the symptom, probable trouble, and correction of the trouble in a hand-driven generator.

c. The two most common troubles that occur in hand-driven generators are defective voltage regulators and problems with the brushes.

**(1) Defective voltage regulator.**

Don't try to repair the voltage regulator if it's defective. It should be replaced with a new plug-in unit.

**(2) Worn, dirty or cracked brushes.**

When replacing brushes (fig 11) be sure to observe the correct polarity markings. For example, in the Generator GN-58 the polarity markings must face upward in the normal operating position of the generator. If you invert the brushes, the commutator may be damaged.

### 13. MAKE A VISUAL INSPECTION OF THE TRANSMITTER CHASSIS

a. After making sure the power supply is operating properly, the transmitter should be inspected before proceeding with steps 4-7 of the troubleshooting procedure. Naturally, before you can make a visual inspection of the transmitter chassis you have to remove it from the case as shown in figure 12 -- then make an inspection.

b. Start at the underside of the chassis and slowly scan the entire unit. If the transmitter appears dirty, you should brush away the dirt that has collected on or between the components. A fine-bristled, soft brush works well for this operation. As you scan the transmitter, here are some of the things you should look for.

(1) Inspect all parts for rust, corrosion, breakage or other damage.

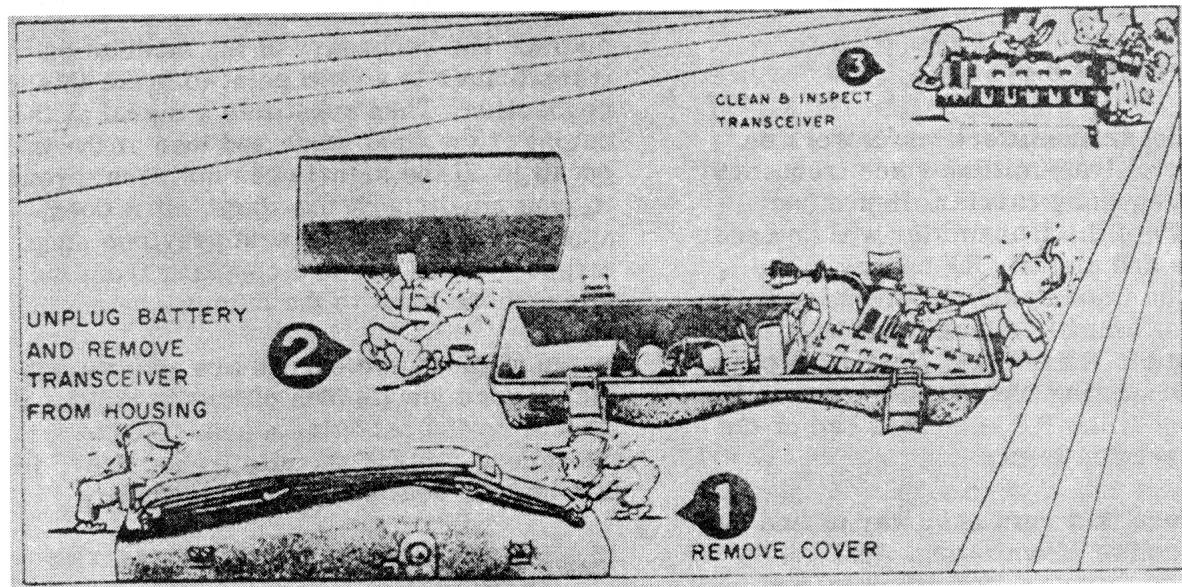


Figure 12. Removing and inspecting the transmitter.

- (2) Inspect wiring for loose connections, frayed or burned insulation.
- (3) Examine lugs on capacitors, transformers, chokes, switches, connectors, and tube sockets for loose connections or breaks.
- (4) Look for loose switches, nuts, bolts, and mounting hardware. Loose mounting hardware, particularly in vehicular sets, may cause intermittent noises which are very difficult to find.
- (5) Inspect all sockets to see if the contacts are broken, corroded or dirty.
- (6) Check all tube shields to see if they are held firmly in their bases, and that the springs are seated properly within the tube shield.
- (7) Examine solder connections for cold-solder joints.
- (8) Look for fixed capacitors that are discolored, leaky or bulging. Melted wax or dielectric material oozing from a capacitor are also signs of damage. Such capacitors should be replaced immediately. Even though the capacitors may check good right now, chances are they'll soon become defective.

(9) Resistors should be given the same careful inspection as capacitors. Look for blistering, discoloration, or other signs of over-heating. Usually a discolored resistor indicates that more current is flowing through it than there should be. Most likely there is a defective component in the same circuit with the resistor that is causing the excess current flow.

(10) Inspect all variable capacitors for dirt, dust or lint. Examine the plates for signs of damage, misalignment, or binding that would cause them to touch other plates during tuning.

(11) Remove covers of enclosed tuning assemblies. Examine the components to make sure they are not damaged.

(12) Examine spring clips and crystal sockets to make sure that the crystal is held firmly in place.

(13) Operate all panel switches to see that they work easily. If you can see switch contacts, look for signs of corrosion, improper contact, and dirt.

c. If the visual inspection doesn't reveal the trouble, then proceed with the systematic troubleshooting procedure. Steps 1-3 have been completed so begin with step 4 -- localizing.

#### 14. LOCALIZING THE DEFECTIVE TRANSMITTER STAGE

a. Most transmitters you'll work on are capable of transmitting voice frequency on a high frequency carrier. Hence one section (RF) of the transmitter will be used to generate and amplify RF energy. The other section (modulator) receives the voice frequencies, amplifies them, and uses them to modulate the RF energy. Your first objective in localizing trouble in a transmitter is to find out if the RF section is bad or the modulator section is bad.

b. There is a very easy way to find out if the RF section is operating. Just take a piece of wood (a ruler, for example) and fasten a neon bulb to it with a piece of wire. Then turn the set on and adjust for normal operation. Hold the bulb close to the RF circuits or coils and, if RF energy is present, the bulb will glow. The brilliance of the bulb indicates the relative strength of the RF energy.

c. The modulator section should be checked using signal substitution. First, connect an indicating device like a loud-speaker or output meter at the modulator

output. The secondary of the modulation transformer is a good point to make this connection. Then substitute a signal at the output of the final stage and then at the input to it. If the signal does not pass through it, you must check the stage. If it does, apply the signal to the next previous stage and so on until you are checking from the microphone input to the output.

d. These two checks are general but they'll give you an idea of how to isolate a trouble to the defective stage. To find the procedure for any specific transmitter, the TM is your best source of information.

#### 15. USING THE TM TO LOCALIZE THE TROUBLE

a. The maintenance portion of the TM provides a lot of good troubleshooting information. First, before you start localizing the trouble, look for the instructions explaining how to arrange the test set-up for the transmitter. They tell you what power supply, antenna and test equipment are needed.

b. After completing the procedure given, look for an operational check chart. Figure 13 is an example of such a chart.

##### 52. Operational Check Chart

CAUTION: Turn off power when making resistance or continuity measurements.

Item of check	Test Condition or operation	Normal indication	Possible causes of trouble	Further checks
(16) Over-all transmitter frequency, tracking and dial calibration.	Same as in item 12. Couple frequency meter to antenna load (N-5). Rotate MCS dial in succession to each of its mc detent positions. Operate push-to-talk switch for each dial position and read frequency meter.	For each setting of the dial the frequency meter shows a frequency which is within 7.5 kc of the nominal frequency indicated by the dial.	(a) MCS control requires re-calibration.  (b) Crystal oscillator-harmonic generator and harmonic amplifier off frequency or defective.  (c) Transmit oscillator off frequency or defective.	(a) Check mechanical alignment (par. 65). Check calibration and alignment with reference to paragraph 55.  (b) Check in accordance with paragraph 54, items 1 through 4. Follow up with mechanical alignment (par. 65) and electrical alignment (par. 71).  (c) Check in accordance with paragraph 54, items 5, 6 and 7. Follow up with alignment (pars. 65 and 72).
(17) Transmitter power output (HIGH power).	Same as in item 12, except as follows: DIAL LIGHT (ON-OFF)-RING switch on RING.  TRANS POWER switch on power supply on HIGH. METER switch on HI.	Meter on front panel reads at least one-half of full scale.	Transmitter high-frequency circuits need alignment (particularly driver and power amplifier stages and antenna circuit).	Align in accordance with paragraph 72, with high power applied.

Figure 13. Part of the Operational Check Chart in TM 11-289.

This chart is very similar to the equipment performance check list used to sectionalize the trouble to a unit of the complete set. The operational check chart differs in that it is used to check only one unit of the complete set. For example, you would use the equipment performance check list to find out if RT-66/GRC was defective in the complete AN/GRC-3 set and then the operational check list to localize the trouble to a stage within the RT-66/GRC.

c. This particular operational check chart is broken down into the following columns.

(1) Item of check. This column specifies what circuits or in some cases what component is being checked.

(2) Test condition or operation. This column explains how to set the equipment operating switches and controls and where to connect the test equipment if any is used.

(3) Normal indication. This column tells you what meter reading should result, what normal indication you should see, or what signal or tone you should hear if everything is OK.

(4) Possible causes of trouble. This column lists the section which may be at fault if a normal indication does not occur.

In some cases, it may indicate which stage is bad, or perhaps even pin-point a defective component. This column frequently indicates tube trouble. If you suspect a bad tube, try substituting a new one and see if the trouble clears up. If you don't have sufficient tubes for checking in this manner, use a tube tester.

(5) Further checks. Always refer to this column after checking the possible causes of trouble. It tells you what additional checks are necessary, how to make them, or what chart to go to that describes the check in detail.

d. In most cases, the operational check on the set will lead you to the defective stage. With that completed, you are ready for step 5 of the troubleshooting procedure -- isolating the defective component within the stage.

#### 16. ISOLATING THE DEFECTIVE COMPONENT

a. A chart for localizing trouble in the transmitter section may also be found in the maintenance portion of the TM. It is used to locate the defective component. Figure 14 shows part of this type of chart.

b. A localizing chart, as shown in figure 14, is usually broken down into the specific stages of a transmitter. It lists the

146. LOCALIZING TROUBLE IN TRANSMITTER SECTION

Symptom	Probable Trouble	Correction
<p>MASTER OSC 3A4 (V101):</p> <ol style="list-style-type: none"> <li>1. Master oscillator does not oscillate on either MO or XTAL position. All d-c supply voltages are normal.</li>   <li>2. Oscillator does not oscillate on XTAL position only. All d-c supply voltages are normal.</li> </ol>	<p>1a. Faulty tube V101--</p> <p>b. Grid coil between terminals 4 and 5 of transformer T101 is open.</p> <p>c. One of capacitors C104, C101A, C102, C12C, and C106B may be shorted.</p> <p>d. Grid resistor R102 is open--</p> <p>e. Capacitor C105 may be open--</p> <p>f. Capacitor C103 may be open--</p> <p>g. Capacitor C104 may be open--</p> <p>2a. If oscillator does not oscillate for only one or two crystals, they are probably defective or switches S101D and S101E are dirty or open.</p>	<p>1a. Replace tube V101.</p> <p>b. Check resistance between 4 and 5. Replace transformer T101.</p> <p>c. Check resistance between terminals 1 and 3 of transformer T101.</p> <p>d. Replace resistor R102.</p> <p>e. Momentarily, short capacitor C105 with one of equal capacity.</p> <p>f. Momentarily, short capacitor C103 with one of equal capacity.</p> <p>g. Momentarily, short capacitor C104 with one of equal capacity.</p> <p>2a. Replace the crystals. Clean or replace the switch sections.</p>

Figure 14. Part of chart, localizing trouble in the transmitter section.

trouble symptom, the possible trouble, and how to correct the trouble within each stage. In most cases the trouble symptom is indicated by an incorrect meter reading or an incorrect voltage or resistance reading.

#### 17. REPLACING DEFECTIVE COMPONENTS

a. The component that is inserted should be the exact duplicate of the original component. When an exact replacement is not available, use a component that has the same electrical properties and is of equal or higher voltage or current rating.

b. Before unsoldering any component, note the position of all leads. After replacing the component, dress the leads so that they're in the same position as before. The distributed capacitance of the wiring may affect circuit operation. Moving the wiring will change the distributed capacitance and thus change the circuit operation.

c. If a part such as a transformer or a switch has many connections, tag each connecting lead before unsoldering. Also, watch out that you don't damage leads of nearby circuit elements when replacing a defective part.

d. Make well-soldered joints and be careful that drops of solder or pieces of

wire do not fall into the set. If the part is one that can be damaged by heat such as a diode or transistor, be sure to use a heat sink.

#### 18. FINAL TESTING THE TRANSMITTER

a. Now that you've found and repaired the trouble in the transmitter you're ready for step 6 -- a final test. Actually, this test is nothing more than a final check to see that all stages in the transmitter are once again in tip-top shape. By making this final test, other faults may also be detected.

b. Figure 15 shows the final test setup for the AN/GRC-10. Generally speaking, when making the final test on a transmitter, there are four important things you should do.

(1) See if the power output of the transmitter is correct. This means you'll have to check the power output over the entire band of frequencies that the transmitter can produce.

(2) Check to see if all of the panel lights and meters are working properly.

(3) Modulator operation must also be checked to see that it is putting out the maximum amount of power.

(4) Check to see if abnormal distortion is present.

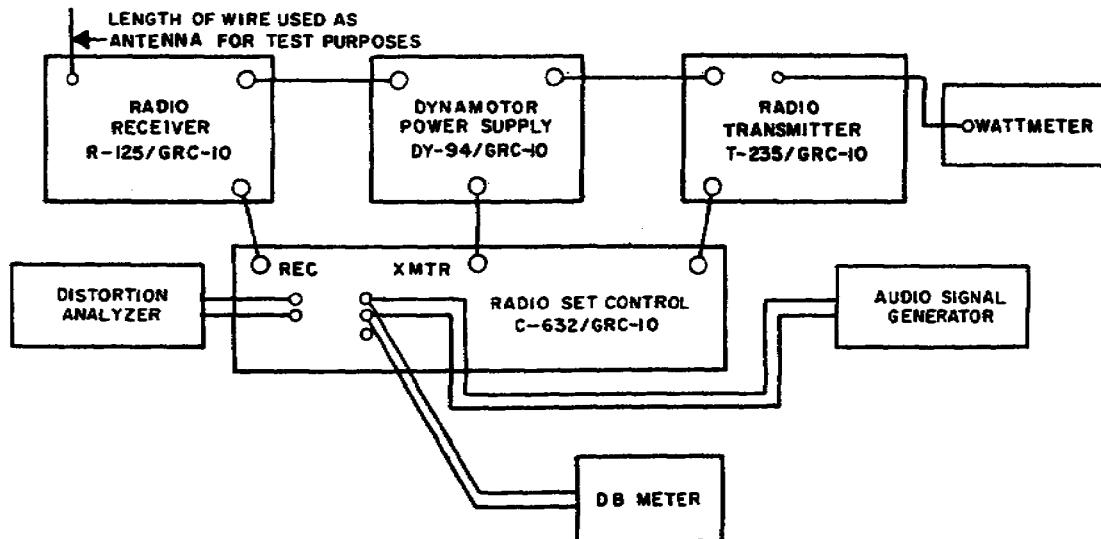


Figure 15. Test equipment setup for the AN/GRC-10.

## ATTACHED MEMORANDUM

### 4-1. BLOCK DIAGRAM OF A HIGH-POWER RADIOTELEPHONE TRANSMITTER

Part of the procedure for troubleshooting a radio transmitter is to localize the trouble to a stage. A block diagram of the transmitter is of great value during this step of the troubleshooting procedure. The block diagram portrays the various stages of the transmitter and shows the interstage connections. A knowledge of what each stage of the transmitter is designed to do will speed the localizing step. Once the trouble has been localized to a stage, the schematic diagram can be used to isolate the trouble to a component. The following is an analysis of the block diagram of a typical high-powered radiotelephone transmitter shown in figure 4-1.

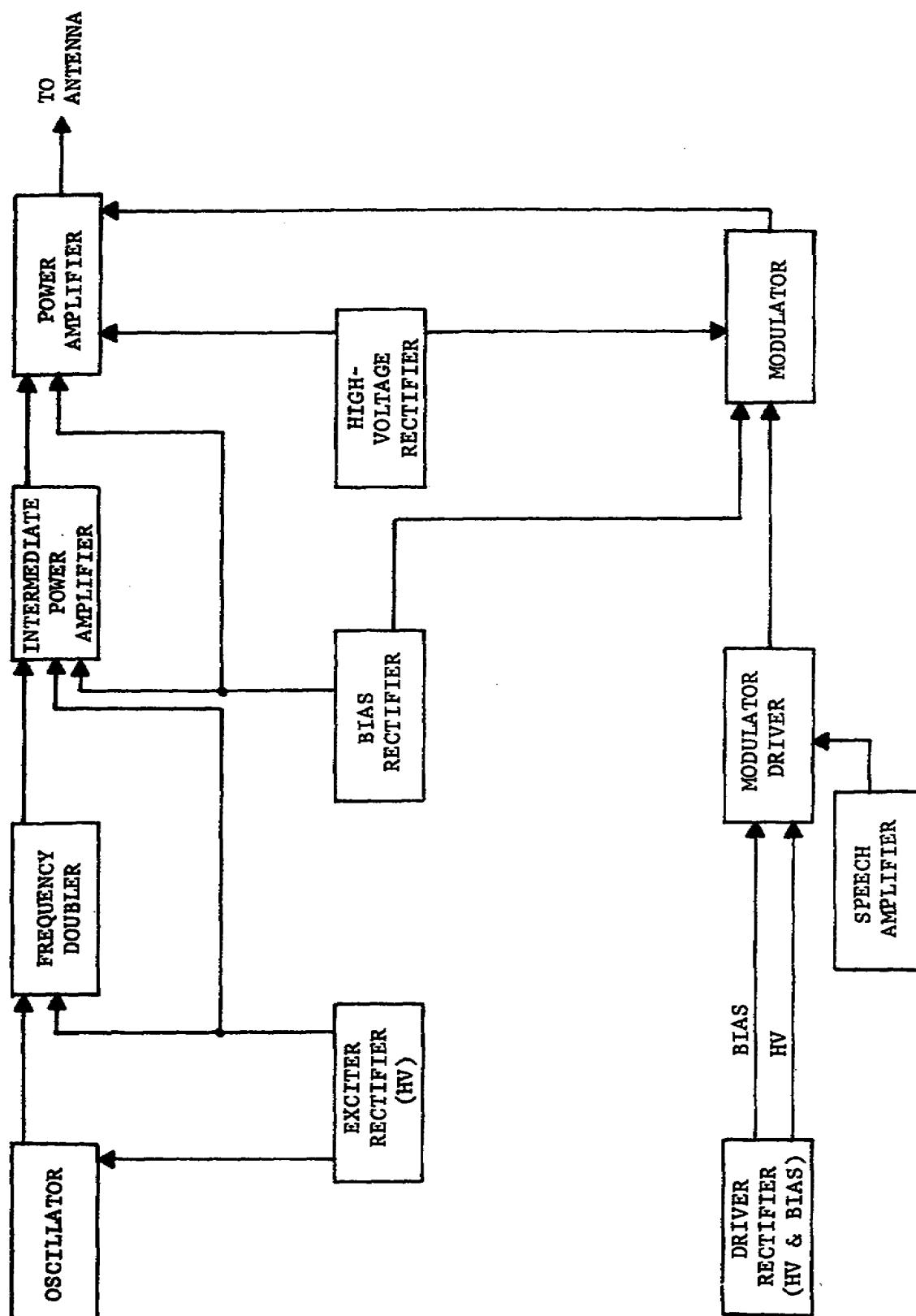


Figure 4-1. Block diagram of a typical radiotelephone transmitter.

a. Power Supply. There are four separate power supplies in this transmitter.

- (1) Exciter rectifier. This rectifier provides high voltage to the oscillator, the frequency doubler, and the intermediate power amplifier. If the tubes are tetrodes or pentodes, voltages for the screen grids as well as the plate voltages will come from this rectifier.
- (2) Bias rectifier. This rectifier provides the bias for the intermediate power amplifier, the power amplifier, and the modulator.
- (3) High-voltage rectifier. This rectifier provides the plate voltage for the power amplifier and the modulator. If either or both tubes are tetrodes or pentodes, the screen grid voltage will come from this rectifier.
- (4) Driver rectifier. This rectifier provides both the high voltage for the plates and the bias voltage for the grids of the modulator driver.

b. RF Stages.

- (1) Oscillator. The oscillator stage may be any one of the various types of oscillators used in transmitters. It will generate a stable RF frequency. Since there is no bias voltage shown for this stage, the oscillator is self-biased. The output of the oscillator stage is coupled to the frequency doubler.
- (2) Frequency doubler. This stage actually serves a dual purpose. First, it is used to amplify the oscillator output and raise the frequency to the desired operating frequency. The second function of this stage is to act as a buffer so that the load of the other stages will not affect the stability of the oscillator. This stage is self-biased and the output is fed to the intermediate power amplifier.
- (3) Intermediate power amplifier. This stage is designed to increase the power of the signal. It may also act as a frequency multiplier. The stage may consist of a single tube or two tubes in parallel. The bias for this stage is supplied by the bias rectifier. The output of the intermediate power amplifier is fed to the power amplifier.
- (4) Power amplifier. This stage will provide the final amplification of the RF signal before it goes to the antenna. In addition, the actual modulation of the RF carrier takes place in this stage. It is here that the AF signal is superimposed on the RF carrier, causing amplitude modulation. The bias for this stage is supplied by the bias rectifier. The modulated carrier is fed to the antenna for radiation.

c. AF Stages.

- (1) Modulation driver. This stage is used to couple the AF voltage from the speech amplifier into the modulator stage. The driver stage is

designed to amplify the audio signal without distorting it. The driver may be a single tube or two tubes in push-pull. The bias for the driver is supplied by the driver rectifier. The signal from the driver is fed to the modulator.

- (2) Modulator. This stage is used to provide the audio power needed to modulate the RF power amplifier. The modulator may be a single tube, two or more tubes in push-pull, or any even number of tubes in push-pull parallel. Any class of amplifier may be used. The class of amplifier used and the circuit arrangement will be determined by the power required to modulate the RF amplifier, and the permissible distortion. Bias for this stage is supplied by the bias rectifier. The output is fed to the final power amplifier, where it is superimposed on the RF carrier and fed to the antenna for radiation.
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## LESSON EXERCISES

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your solution by circling the letter opposite the correct answer in the subcourse booklet.

### SITUATION

Assume that you are attached to a signal unit that has received a shipment of low-power radio transmitters for use in the field. A schematic diagram of this transmitter is shown in figure 133 of TM 11-665.

Exercises 1 through 6 are based on the above situation.

1. The oscillator tank circuit consists of coil L1 and capacitor
  - a. C1.
  - b. C3.
  - c. C4.
  - d. C6.
2. The function of capacitor C6 is to
  - a. balance the reactance of C4.
  - b. transfer the oscillator output to the antenna.
  - c. couple the oscillator output to the amplifier input.
  - d. neutralize the interelectrode capacitance of V2 to prevent oscillation.
3. Capacitor C2 serves as a common cathode return for two RF circuits. These two circuits include the

- a. plate and grid of V1.
  - c. grid of V1 and grid of V2.
  - b. plate and grid of V2.
  - d. plate of V1 and plate of V2.
4. The function of inductor L3 in this circuit is to
- a. provide regenerative feedback.
  - b. provide degenerative feedback.
  - c. prevent AF from entering the oscillator.
  - d. prevent RF from entering the power supply.
5. Grid bias voltage for modulator tubes V4 and V5 is developed as a result of grid current flow in
- a. V1.
  - c. V3.
  - b. V2.
  - d. V4 and V5.
6. How is the modulating voltage applied to RF amplifier V2?
- a. Through L4, in series with the grid voltage
  - b. Through L4, in parallel with the grid voltage
  - c. Through T4, in series with the dc plate voltage
  - d. Through T4, in parallel with the dc plate voltage

#### SITUATION

Assume that you have been assigned to a transmitter site. You will be responsible for maintaining several transmitters in the station. The schematic diagram for one of the transmitters is shown in figure 134 of TM 11-665.

Exercises 7 through 14 are based on the above situation.

7. The oscillator stage in this transmitter can best be identified as a
- a. modified Hartley oscillator.
  - b. modified Colpitts oscillator.
  - c. tuned-plate, tuned-grid oscillator.
  - d. modified electron-coupled oscillator.
8. Most high-power radio transmitters have meters to permit operators and maintenance men to electrically monitor the operating conditions of the individual stages. The meters that measure grid currents are



15. Assume that you are troubleshooting a radio transmitter. When you are "localizing" you are trying to determine

- a. which unit of the transmitter contains the trouble.
- b. which component is causing the trouble.
- c. which stage contains the trouble.
- d. whether there is a bad tube.

16. Assume that a radio transceiver is inoperative. When the repairman has made the visual inspection, determined that the trouble is in the transmitter, and checked the power supply, he will then proceed, in order, to

- a. localize, test, isolate, and replace.
- b. test, localize, isolate, and replace.
- c. isolate, localize, replace, and test.
- d. localize, isolate, replace, and test.

17. The third step in troubleshooting a transmitter is to check the power supply. If the power supply is of the rectifier type, you should not turn it on until AFTER you have

- a. checked the rectifier tube.
- b. checked the filter capacitors.
- c. measured the value of the bleeder resistor.
- d. made a resistance check of the B-plus circuit.

18. A dynamotor is often used in a transmitter to supply the necessary voltages. A dynamotor is a device that uses

- a. a dc generator to drive an ac motor.
- b. an ac generator to drive a dc motor.
- c. a dc motor to drive an ac generator.
- d. a dc motor to drive a dc generator.

19. Assume that you are troubleshooting a transmitter. A block diagram is most useful to you when you are

- a. isolating the defect to a component.
- b. replacing the faulty component.

- c. making the final check.
  - d. localizing to a stage.
20. In figure 4-1 of the attached memorandum, one block represents all the components and tube or tubes used in the modulator stage. What determines the circuit arrangement and class of amplifier used in this stage?
- a. The method of modulation being used
  - b. The type of tube or tubes being used
  - c. The amplitude of the modulating voltage
  - d. The power requirement and permissible distortion of the stage

CHECK YOUR ANSWERS WITH LESSON SOLUTION SHEET # 4, Page(s) 45.

HOLD ALL TEXTS AND MATERIALS FOR USE WITH EXAMINATION AND SIG 322.

## LESSON SOLUTIONS

SIGNAL SUBCOURSE 321.....AM Radio Transmitters

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LESSON 1.....CW Radio Transmitters

All references are to TM 11-665.

1. b--para 3a
2. a--para 3e, chart in para 3d

The wavelength of 3,000 meters is equivalent to 100 kHz:

$$F = 300,000,000/3,000 = 100,000 \text{ Hz or } 100 \text{ kHz}.$$

The wavelength of 4,500 meters is equivalent to 66.7 kHz:

$$F = 300,000,000/4,500 = 66.7 \text{ kHz}.$$

The frequency range of 66.7 to 100 kHz is within the low frequency (LF) band.

3. b--para 53a
4. b--para 55c
5. c--para 55d(1), fig. 71

If a sufficient number of stages is used, the CW transmitter can be arranged to operate on 10 MHz, 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 320 MHz, since each doubler simply doubles the frequency of the preceding stage. The transmitter cannot be operated on 50 MHz, 60 MHz, or 100 MHz because the stages in the transmitter are either fundamental frequency amplifiers or doublers.

6. a--para 56a
7. b--para 56a, d
8. b--para 56c(2)

9. b--para 56d
  10. d--para 60d
  11. c--para 61b
  12. b--para 61e
  13. c--para 61e
  14. b--para 63g
  15. c--para 63i(2)
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## LESSON 2 .....Amplitude Modulation

All references are to TH 11-665.

1. c--para 71d(2)

$$P_{\text{mod}} = \left[ 1 + \frac{m^2}{2} \right] \times P_{\text{carr}}$$

For 100-percent modulation:

$$P_{\text{mod}} = \left[ 1 + \frac{(1)^2}{2} \right] \times 500 = 750 \text{ watts, and}$$

$$P_{\text{sideband}} = P_{\text{mod}} - P_{\text{carr}}$$

$$P_{\text{sideband}} = 750 \text{ watts} - 500 \text{ watts} = 250 \text{ watts.}$$

For 70-percent modulation:

$$P_{\text{mod}} = \left[ 1 + \frac{(0.7)^2}{2} \right] \times 500 = 622.5 \text{ watts, and}$$

$$P_{\text{sideband}} = 622.5 \text{ watts} - 500 \text{ watts} = 122.5 \text{ watts.}$$

Reduction of sideband power is approximately 128 watts.

100 percent modulation: 250.0 watts

70 percent modulation: 122.5 watts

Reduction	128	watts
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2. b--para 72b(2); fig. 108

3. a--para 73a

4. a--para 73b

5. c--para 74a(4)
6. d--para 75a(3)
7. c--para 73c(2)
8. b--para 75d(2)
9. c--para 76d

When a positive input signal is applied to the cathode of an amplifier, it has the same effect as a negative signal applied to the control grid. Both will cause a decrease in plate current ( $I_p$ ) and an increase in plate voltage ( $E_p$ ). A negative input signal to the cathode causes an increase in  $I_p$ .

10. b--para 76e
11. b--para 77c
12. a--para 77c
13. d--para 78b(5), d(2)
14. b--para 79b
15. a--para 79e(1), (3)
16. c--para 80
17. c--para 81a(2), b(2)
18. c--para 81a(3)
19. d--para 81c(2)
20. a--para 82b

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## LESSON 3 .....Transmitter Circuit Analysis

All references are to TM 11-665.

1. c--para 57b(2)
2. b--para 57c(3)
3. d--para 57d(2)
4. d--para 57e

5. c--para 58b(1)

$$\mathbf{E}_c = \mathbf{E} \times \frac{\mathbf{X}_c}{R}$$

$$E_c = 2 \times \frac{600}{4}$$

6. c--para 58b(1)

7. c--para 58c(4)

8. c--para 59a(1)

9. c--para 59a(1), 66a(2)

10. b--para 59a(2)

11. d--para 59b(4)

12. d--para 59b(6)

13. b--para 64a(1)

14. c--para 64a(2)

15. a--para 64b(3)

16. a--para 65b(1)

17. b--para 65b(2)

18. c--para 66b(1)

19. a--para 66b(2) (b)

Oscillator frequency = 2.65 MHz

1st multiplier as tripler =  $2.65 \times 3 = 7.95$  MHz

2d multiplier as quadrupler =  $4 \times 7.95 = 31.8$  MHz

20. c--para 66b(5)

## LESSON 4.....Troubleshooting Procedures

All references are to TM 11-665, unless otherwise indicated.

1. a--para 83a
2. d--para 83a
3. a--para 83a
4. d--para 83a
5. b--para 83b
6. c--para 83b
7. d--para 84a(1)
8. a--fig. 134
9. b--para 84a(2)
10. c--para 84a(2), (3)

The buffer-doubler tank circuit (C32-L7) is tuned to the second harmonic of the oscillator frequency. This frequency, which is twice the oscillator frequency, becomes the input signal to the intermediate power amplifier (IPA). With the IPA tank circuit tuned to the second harmonic of the input frequency the output from the IPA will be the fourth harmonic of the oscillator frequency.

11. d--para 84a(3)
12. d--para 84a(3)
13. a--para 84a(3)
14. c--para 84a(3); Addendum 1, para 9c(5)
15. c--Addendum 1, para 4b(4)
16. d--Addendum 1, para 4b(1) thru (7)
17. d--Addendum 1, para 9a
18. d--Addendum 1, para 11
19. d--Attached Memorandum, para 4-1
20. d--Attached Memorandum, para 4-1c(2)